Center for Independent Experts (CIE) Peer Review Report of Methods Review of the Canadian Swept-Area Trawl Survey conducted along the West Coast of Vancouver Island for Inclusion into the Pacific Sardine Stock Assessment

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1. Executive Summary

We identified six aspects which provided a focus for discussions during the review:

i. design of the trawl sampling, representativeness of the data for the density of Pacific Sardine;
ii. Spatial sampling and raising to area, evaluation of potential biases in sampling design and analysis;
iii. overall applicability of biomass estimates as an index or absolute abundance;
iv. methodology of estimates of size and age proportions;
v. estimates of variance by year;
vi. suitability of West Coast of Vancouver Island (WCVI) trawl survey estimates for use in stock assessments and management advice for Pacific sardine.

Linda Flostrand and Jake Schweigert of the Department of Fisheries and Oceans (DFO Canada) provided presentations on History of the WCVI Trawl Survey and WCVI Trawl Survey Methods and Result. Paul Crone, of the Southwest Fisheries Science Center (SWFSC), National Marine Fisheries Service (NMFS), presented background for the Inclusion of the WCVI Trawl Survey in the U.S. Sardine Assessment.

The WVCI Survey Report presentations and additional work carried out during the review provide a good basis to evaluate the performance of the WVCI trawl survey. They indicate that the survey is currently being performed in a way that should allow a consistent index of abundance for Pacific sardine in Canadian waters to be produced.

The WVCI trawl survey time series can be considered to give estimates of distribution of abundance of Pacific Sardine for the survey area. Minor reanalysis is required to update estimates of precision for some years. Some limited exploration is required to evaluate the sensitivity of the abundance estimates to tow length and time of day. Some model and index development is required primarily to determine the proportion of Pacific sardine in Canadian waters at the time of the survey, before the best use of the survey can be obtained within the assessment. To accompany the use of the index in the assessment it would be beneficial to develop a detailed survey manual.

2. Background

The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. A Statement of Work (Annex 2) is established by the NMFS Project Contact and Contracting Officer's Technical Representative, and reviewed by the CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee. Further information on the CIE process can be obtained from www.ciereviews.org.

This independent reviewer was requested to participate in a panel-review meeting to conduct independent peer review of methods used in the Canadian Swept-Area Trawl Survey conducted along the West Coast of Vancouver Island (WCVI) and advise on its inclusion into the Pacific sardine stock assessment. The survey area is predominantly the shelf area off the west coast of the Vancouver Island. The latitudinal and offshore extents of the Pacific sardine are seasonal, extending further north in the summer and further offshore in the spring. Survey estimates are to give either absolute biomasses or an index of biomass, their total random sampling errors, age and length structure, and spatial distributions. The review concerns technical aspects of the survey design, method, analysis, and results and how this might be used in an assessment of the whole Pacific sardine stock.

3. Reviewer's Role in the Review Activities

I am an expert in Fisheries surveys, and their use in the assessment of pelagic stocks and their use in fish stock management. My background is that of a senior fisheries scientist Aberdeen, UK. Currently I work under short term contract chairing the development of fisheries management plans for the European Commission Scientific committee STECF. Before this I have worked in fisheries research for 39 years mostly at FRS Marine Laboratory Aberdeen in Scotland and for the last two years at European Research Centre JRC, Ispra Italy. I have worked with acoustic and trawl surveys for pelagic species for more than 30 years and carried out stock assessments involving acoustic-trawl, trawl and egg surveys for more than 15 years. I am the author of books on Geostatistics (2000) and Fisheries Acoustics (1991 and 2nd Edition 2005). I have been responsible for developing approaches for combining acoustic-trawl, trawl and ichthyoplankton surveys in assessments for North Sea herring. I have worked on absolute assessments based on Total Annual Egg Production methods for North Eastern Atlantic mackerel. I have been involved in acoustic-trawl surveys for sardine and/or anchovy off Morocco, and in the Persian Gulf, the South China Sea, Ecuador and Peru. Since 1990 I have developed extensive experience of fish stock assessment and fisheries management, chairing among other groups the ICES herring survey planning group 1991-95, the ICES Fisheries Acoustics WG 1993-96, the ICES herring assessment working group 1998-2000, and the ICES study group on Management Strategies from 2004-2009. I currently chair the STECF group that prepares evaluations of historic performance of management plans and the impact assessments for new multi-annual fisheries management plans.

I participated in all aspects of the review, paying particular attention to survey design and station allocation, calculations of sardine density, survey biomass and its variance, and the utility of the results as a relative index of abundance within the current SS3 assessment for Pacific sardine.

4. Findings by Term of Reference

As required by the ToR the body of this report is organized under the following main sections:

- Review documents pertinent to the topic under consideration,
- Evaluation of the technical merits and deficiencies of the proposed methods,
- Recommendations for alternative methods or modifications to proposed methods,
- Recommendations on application of the methods to the stock assessment.

In addition to the details provided under this structure, the report contains overall conclusions (Section 5) and a summary of collected recommendations (Section 6).

4.1. Review of documents

One primary document was provided; Canadian west coast of Vancouver Island (WCVI) summer sardine research trawl surveys, 1999-2011. In addition 22 papers or reports (listed in Annex 2) were provided as background for the work. On the first morning Linda Flostrand and Jake Schweigert of the Department of Fisheries and Oceans (DFO Canada) provided presentations on History of the WCVI Trawl Survey and WCVI Trawl Survey Methods and Result. Paul Crone of the Southwest Fisheries Science Center (SWFSC), NMFS, presented background for the Inclusion of the WCVI Trawl Survey in the U.S. Sardine Assessment. This occupied the full day during which ten aspects were identified for further investigation and presentations. These additional aspects were prepared by the survey group and presented during the remaining two days. All the documentation was provided in good time before the meeting, it was well laid out and clear. Most of the survey documentation concentrated on the results. Generally the survey documentation is in the early stages of development and does require some additional material to describe in more detail the survey data collection protocols and analysis methods, nevertheless the reports provided give an excellent start. The survey team members should be commended for their cooperation and hard work, particularly with the additional aspects that were requested during the meeting.

4.2. Evaluation of the technical merits and deficiencies of the proposed methods

This section details the review of survey methodology, including gear type, deployment, survey design and data analysis, The recommendations arising from this are given in the next section (4.3) under matching headings

4.2.1. Gear and Instrumentation

The Panel carried out the evaluation of the WCVI Canadian survey equipment and protocols relative to international standards (e.g. Reid et al. (2007) and ICES (2009)) which document international efforts to identify conventions that are applicable for most areas and conditions.

Choice of trawl

In general, sampling of small pelagic fishes by trawl is challenging due to their high swimming speed and sensitivity to external stimuli, such as moving and noisy trawling vessels (Misund et al 1999). A suitable trawl should sample a large enough volume and be constructed so as to allow high towing speed and thus enhance catching efficiency. All WCVI surveys were conducted using a model 250/350/14 midwater rope trawl (Cantrawl Pacific Ltd., Richmond, B.C.). This is a relatively small pelagic trawl which appears easy and robust in routine operations. As such, it is a suitable survey trawl though the small size of the net opening increases the possibility of fish avoiding the gear (Suuronen et al. 1997, Misund et al. 1999).

Trawl geometry

The trawl is documented using drawings of trawl construction and rigging, including door specifications. However, some of the figures provided to the Panel were drawn by hand and were not always easy to interpret.

Conducting swept area surveys requires both a knowledge of trawl geometry, to enable area or volume densities to be calculated, and also fish behaviour around the gear in order to assess not just the physical volume but the effective volume that the caught fish originally occupied before they were disturbed by the vessel and gear.

Catches from trawls are sensitive to environmental conditions such as strong currents and winds, as well as operational mistakes. This may seriously impact the trawl geometry (height and width) and thus the trawl opening, which is basic information for estimating densities. Also, operating the trawl at depth in accordance with survey protocols is demanding. The trawl net for the Canadian trawl survey is always equipped with trawl sonar (Simrad FS-70) attached to the head line. This style of trawl sonar is an ideal instrument for checking the operation of the net, to monitor the trawl opening, and check the trawl is functioning with stability at target geometry. Also, this instrument delineates the outline of the trawl, which can be used to assess the geometry and by inference the amount of water filtered by the trawl. Based on the construction of the trawl and its rigging, as given in the trawl drawings, the footrope is expected to be located directly under the headline. Assuming that the sonar is attached to the midpoint of the headline, it will describe the trawl opening at this part of the trawl, some distance behind the wing-ends and even further behind the trawl doors. The wing-ends cover a wider area than that shown by the trawl sonar, and it could be argued that the trawl opening at the wing-ends is more relevant for assessing densities because fish are probably herded by the wings. This is an issue if catches are expressed as absolute densities, but is of minor importance for calculation of indices of relative abundance.

Operational procedures

Operational protocols are important when ensuring each tow is carried out correctly and thus deciding on the validity of tows. Without such protocols *ad hoc* decisions by personnel on watch may lead to bias and add to the variability of the results. There are fixed routines for operating the trawl at a standard tow location, but there seems to be no protocol for handling sonar observations with respect to the deviation from standard specification; i.e. how much deviation in geometry can be tolerated before the tow is discarded, or stopped and repeated. Presently this is a decision taken by the fishing master on watch. The lack of protocol is particularly an issue when a fishing skipper changes or when the current one in charge leaves. To achieve standard operation of the gear, there is a need for operational specifications that describe accepted variation in geometry measures before trawling is terminated and repeated (see, for example, Walsh et al. (2009)).

4.2.2. Calculation of point density from catch data

A swept area/volume assessment of fish density requires that the properties of the gear and its operation are known. The effective opening of the trawl: the area effectively herding fish into the trawl (see above) needs to be defined, measured and monitored. The opening of the trawl has been defined as the area covered by the trawl sonar in the case of the WCVI surveys. As noted above, this is likely to be a smaller area than that over which fish are herded, but it is the ideal area to measure and monitor, and is thus a good choice for calculating relative estimates of densities.

Distance towed is needed to calculate swept volume. Currently this is based on GPS records of speed over the ground multiplied by the tow duration. However, this might be an imprecise estimate of distance towed due to uncertainty measuring tow speed. Such uncertainty may explain some of the apparently large variation in tow speeds recorded during the surveys (although this variation could also be due to strong currents). Some changes should be considered. Ideally volume of water filtered would be the most appropriate measure, though as a first step a more precise measure of distance towed would be an improvement, such as the distance between the GPS position at start and stop, which avoids the need for an estimate of tow speed. Distance over the ground might be an imprecise measure of filtered volume if currents are strong. Nevertheless, it is probably better to use the distance over the ground than trying to assess filtered volume, by for example, recording the speed of water through the trawl. Use of flow meters such as those used on ichthyoplankton surveys might be difficult to use on a trawl gear, so an alternative using a vessel mounted ADCP to give additional current vector added to the tow distance might be applicable if such additional instrumentation is available.

Tow distance/ duration

The WVCI Survey Report indicates a wide range of tow durations (or distances). The report indicates that there were occasions when tows were extended and truncated. It is important that such changes to tow duration are not influenced by observed abundance. In addition the WVCI Survey Report describes instances when catching might have taken place during shooting/retrieval. Thus, the effective distance towed might be longer than that recorded. This is particularly a problem when the distance towed varies. Catching during shooting/retrieval will affect short tows more than long tows. Therefore tow duration should be kept as constant as possible and this issue should be borne in mind as a potential bias when analysing the data. Further, setting the tow start as soon as the standard opening is established and stopping the trawl when trawl geometry is distorted might be a way of minimizing these impacts. Catching during shooting and retrieval is particularly a problem if the distribution of the fish requires that trawling take place at various depths. In such situations, opening-closing devices for the cod end could be a solution, although good techniques for fast swimmers such as sardines might not be readily available.

Tow Catchability

Catchability is a measure of observed trawl density in relation to true density, often described by ‘q’. While, in general, q might impact density by size, in the case of small pelagic fishes it will predominantly affect density measures, while size selection is considered less likely to be important. The trawl is towed at or near the surface for a certain duration in the case of the WCVI survey so the major factors are expected to be associated with vessel avoidance (Gerlotto et al. 2004) and trawl avoidance (Suuronen et al. 1997) and depth distribution. Quantification of these factors is often difficult due to unpredictable variability and difficulties in obtaining appropriate measurements. Nevertheless, the issue should not be ignored because the trawling in the WCVI survey is taking place close to surface, and there is a short distance between the vessel and the trawl. Some straightforward studies could be implemented to monitor avoidance. For example, a vertical profile of the fish distribution under the vessel may be obtained if the vessel acoustics are monitored continuously. Similarly, the trawl sonar (FS-70) could be used to establish a depth distribution profile in the mouth of the trawl. More importantly it may be able to detect if concentrations are seen above or below the net, though the vessel wake may in practice make this difficult for the kind of shallow tows carried out on this survey. There are many sources of uncertainty when comparing those two profiles, but large impacts in the zone between the vessel and the trawl could be identified, but probably not quantified sufficiently to measure catchability. Further, dedicated studies of avoidance, as for example work similar to that done for the CPS acoustic-trawl survey, would be useful to obtain an overview of the impact of these problems.

4.2.3. Definition of the core area

The issue here is how should the boundaries of a core area be specified. If a survey is to be defined, and tow locations set, the area must be defined either in advance or adapted during the survey but in either case in a way that is coupled to the analysis to ensure the results are unbiased. The current (2011) proposal for the core area appears reasonably sensible, but could be modified slightly to make the rationale for the boundary more explicitly based on data and to deal with one or two minor additional aspects.

Given that this is a Canadian survey, the southern boundaries for the survey are administrative and can conform to the Canadian/US border. As the stock extends well inshore, based data presented on the location of the fishery, the eastern boundary should be located as close to the coast of Vancouver Island as is practical. As the fisheries appear to be close inshore and can take place in some of the bays and inlets, it would be helpful to include those areas covered by the fisheries, if possible, thus giving the survey direct relevance to those involved in the fishery. Use of a random placement grid (see below) will then apportion tows to these areas appropriately. The northern and western boundaries need to be set to include the substantive limits of the distribution of sardine. It is probably not possible to cover all areas in which sardine can occur, and excluding a small amount of low density area is reasonable. No survey catches of sardine above $1t/km^3$ have been reported north of Vancouver Island, and some catches at higher densities are observed a few miles south of this line. It seems reasonable to limit the northern extent of the area by this geographically-located point. The westward extent of the survey is more difficult to specify. Catches above 1t/km^3 are observed out to 45km and the 1000m depth contour. Defining the survey boundary by the greater of these two criteria would contain all previously observed densities >1t/km^3. Having delineated the area in this way it may not be necessary to put the same survey effort into each part of the whole area. Stratification and determination of habitat are discussed below and might be used to allocate survey effort.

4.2.4. Influence of environment (habitat)

Sardine habitat has been defined as waters between 12 and 16 ºC off southern and central California. (Zwolinski et al, 2011). High densities, and spawning were observed off Oregon between 14 and 16 ºC. The appearance of sardine off western Vancouver Island is associated with waters warmer than 12 ºC (Ware, 1999). Zwolinski et al (2011) compared sardine egg presence and remotely-sensed information over a 12-year period to define sardine potential habitat, in terms of the oceanographic conditions for the migrations and matching seasonal of the fisheries. The duration of the availability of sardine habitat off western Vancouver Island is shorter than that off Washington and Oregon, suggesting a 4 to 6 month sardine season. Whilst suitable habit may not infer presence, the absence of suitable habitat does suggest a very low probability of presence.

Detailed analysis of the appearance of sardine off the Columbia River mouth suggests that sardine arrive, in general, 2 to 4 weeks after the arrival of the habitat, and peak densities occur generally 1 to 2 months later than this. Information on sardine arrival off western Vancouver Island and its relationship to the potential habitat has not yet been explored, and could benefit from data from scouting trips. Fishery landings suggest that the peak abundance of sardine off Vancouver Island is delayed in relation to the peak of potential habitat, but allocation of fishing quotas could be biasing this conclusion.

There is potential to use this or a similarly defined habitat as a tool for allocating effort within the suggested core area (see above). Also there is a need to develop an annual migration index relating the proportion of the stock in Canadian waters, there may be potential to use this habitat data to provide such an index.

4.2.5. Stratification of the survey area

The issue here is whether the core area should be split into strata and if so at what scale. The WVCI Survey Report gives some evidence for different mean densities around the area. For example, some surveys show low offshore densities and the northern part of the region often has lower estimated densities. In addition, the WVCI Survey Report indicates that biological parameters change latitudinally and this was explored further during the meeting. If the latitudinal variation in biological information is to be included in the analysis, some stratification is required to assign / raise spatial biomass and biological parameters. There is no particular way from the current data to set stratum boundaries to predictably reduce variance, rather the function of stratification is to spread sampling more evenly across the area and allow regional estimates with different biological characteristics to be obtained. The current approach of 8 strata splits the sampling with strata and samples per strata at a similar magnitude. This appears to be a reasonable approach, but the trade-offs in choosing number of strata could be tested by simulation.

4.2.6. Trawl location design (random/ systematic)

The issue here is what would be the optimal placement of tows within the core area. The WVCI Survey Report shows that historically the survey has had changing tow location design over the years. The surveys in 1999-2004, 2006, 2008 and 2009 generally followed similar approaches spatially, a series of tines or transects of tows with the addition of more tows in what appears to be a haphazard fashion. The 2005 survey was aimed primarily at comparing day and night tows rather than achieving good spatial coverage. The surveys in 2010 and 2011 are based on random designs, but with a slightly different area basis.

In 2005 ICES held a workshop on survey design for both trawl and acoustic surveys. A variety of designs were tested on simulated stock distributions with different spatial properties during this workshop. Systematic and random punctual surveys (trawl surveys) were evaluated. The two simulated spatial distributions (Section 2.1.1 of ICES (2005)) with properties similar to observed fish populations, were used to evaluate the differences between a systematic survey design and a fully random survey design. The trial was blind, with participants unaware of the location of the occupied and unoccupied regions and the centres of high density within the survey area. The fields tested were as follows

Field 1:

Coefficient of variation = 3.3
Mean fish density in the field of presence = 4 107 ind n.mi.$^{-2}$
Total abundance = 107 ind
Variogram = nugget effect (sill = 2.5 106 ind2 n.mi.-4) + spherical (sill = 8.3 106 ind2 n.mi.$^{-4}$; range = 10 n.mi.); the nugget effect represents 23% of the total variance.

Field 2:

Coefficient of variation = 1.7
Mean fish density in the field of presence = 4 10^7 ind n.mi. $^{-2}$
Total abundance = 10^7 ind
Variogram = nugget effect (sill =0.23 10^6 ind^2 n.mi.$^{-4}$) + spherical (sill = 2.25 10^6 ind^2 n.mi.$^{-4}$; range =25 n.mi.); the nugget effect represents 9% of the total variance.

In order to compare random and systematic designs the two methods each with 1,000 different sampling realisations taking equal amounts of time were defined as the following:

- **Systematic:** a regular grid of 64 tow locations, arranged in an equally-spaced 8 by 8 grid, with a spacing of 1/8 of the survey dimension with a 2D random location on a scale of 1/8 by 1/8 of the dimension of the area.
- **Random** tow locations; the procedure starts with 64 randomly located tows; the number of tows is then increased by adding new random tows and checking for

time available using the travelling salesman algorithm to give the optimum track until the maximum number possible in the time allocated is reached. The number of tows for each of the 1,000 random sampling realisations is given in Figure 1. This illustrates the increase in the number of samples that can be achieved with a random grid and a travelling salesman algorithm.

The results of the simulations were evaluated through examination of the distribution of the estimates of the total abundance for each method. These distributions are given separately for each simulated surface in Figure 2. For both methods and both simulated surfaces the estimates of mean abundance are unbiased at $1*10^7$. Figure 2a shows the results from simulated surface 1, which has high variance and low spatial autocorrelation. In this case, the results indicate that the random survey design, which has the higher number of observations, has the lower root square error (RSE) (49%) and provides a more precise estimate than the systematic survey (RSE = 56%). Figure 2b shows the results for surface 2 with the lower variance and higher spatial autocorrelation. In contrast to surface 1, the improved precision due to even allocation of sampling with the systematic survey improves the estimate of abundance over the random survey. In this case, the systematic survey RSE is 14%; even with extra samples the RSE for the random survey (23%) is poorer. These contrasting results for the two spatial distributions show that there is an interaction between spatial autocorrelation and sampling design. Further investigation of a wider range of surfaces with different properties would help to refine the parameters that influence when each survey strategy is the most efficient estimator of the abundance and variance.

I am not aware of work that can explicitly determine the correct approach for the WCVI survey. It might be possible to simulate a range of spatial distributions based on the observations. However, this may not be necessary. The analyses of spatial variance carried out during the meeting on the data from the WCVI survey from 1999 to 2011 suggests that there is spartial autocorrelation, but that this is limited to a distance that is a small proportion of the length of the core area. Consequently, it is likely that the WCVI is more like the low correlation surface tested during the ICES workshop, i.e., the ratio of range to the dimension of the area is more important than the absolute range. If this is the case, a random design augmented by an algorithm to maximise the number of tows would likely be the optimal choice. The shape of the area may also affect the results as a long thin area may have less potential for aditional stations under the random design compared with the simple rectangle used in simulations. Thus the gains in precision may not be a great. Nevertheless this work generally supports the current approach of random tow allocation. The current methodology uses a 10 by 10 km grid for tow allocation of ~4 km tows. This results in only 3 times the number of potential locations with respect to the number of tows carried out. This results in a hybrid design, rather more systematic in its station locations than intended. The randomness would be increased by increasing the ratio of number of stations to potential locations one way to do this would be to match the grid size to the trawl length.

The current review has considered only the collection of trawl samples spatially. If the survey was to develop to include acoustic transect data as well, the random placement of tows might no longer be optimal and should be considered again. If systematic locations were chosen under these circumstances, then the variance estimator would need to be changed (see below).

4.2.7. Influence of migration (within area)

Evidence of temporal change in the population (meaning changes during the survey) may influence how the data are collected. Migration of the stock is the most likely temporal issue, and this applies to any survey whether by trawl or acoustic methods. The WVCI Survey Report, the information on the seasonality of the fishery and the evaluation of habitat (Zwolinski 2012) all support the hypothesis of a migrating stock, part of which migrates into Canadian waters for a period of a few months each year. Thus, migration in from the south and subsequent migration out to the south is the most likely model for stock movement. This leads to the need to consider how a survey might interact with migration. The following discussion is taken from Simmonds and MacLennan (2005) and rewritten in the context of trawl tows rather than acoustic transects.

The movements of fish can be conceived as having two components, random motion and a residual vector, the migration. In the former case, random motion, the fish swim at a particular speed in directions that change randomly with time. In the latter case, migration, the fish swim consistently in the same direction. Simmonds et al. (2002) used a fine-scale model of North Sea herring schools, based on a spatial grid covering 120,000 km^2 with a node spacing of 40m, to study the effect of fish movement on the results of simulated surveys. They found that reasonable amounts of random motion were unimportant to estimates of stock abundance or survey variance for either systematic or random survey designs. However, the effect of migration even at a modest speed could not be ignored. As indicated above it is well known that Pacific sardine migrate over long distances on an annual cycle. One factor in the survey design is the timing in relation to the migration cycle, which should ensure that the surveyed area includes the entire stock. However, even if this condition is met, migration of the stock within the surveyed area can bias the abundance estimate. In the cases of the WVCI survey the whole stock is not covered but it is anticipated that the Northern boundary of the stock will move during the survey. The extent of the bias depends on the rate and direction of the migration in relation to the vessel motion.

Suppose the fish are migrating at speed v_f, and v_s is the speed at which the survey progresses in the direction of migration. If v_f and v_s are positive, this means that the fish tend to follow the vessel as it travels through the area. If the tows were drawn on a map whose frame of reference moved with the fish, the tows would be closer together than those on the geostationary map. Thus, the effective area applicable to the analysis is less than the actual area surveyed. The observed point densities estimated from the trawl are unbiased, but since the abundance is the mean density multiplied by the effective area, the estimate of abundance $\hat{Q}$ is biased. The expected value of $\hat{Q}$ is

$$E(\hat{Q}) = Q(1 + v_f/v_s)$$

where Q is true abundance. If v_s is negative, this means that the fish tend pass the vessel as it travels through the area and the bias is negative. Note that v_s is much smaller than the cruising speed of the vessel when the direction of vessel motion from tow to tow is generally perpendicular to the migration. For example, if the cruising speed is 5 ms^{-1}, and the rate of progress along the direction is reduced to 1/10 as the vessel zig-zags between tows and stops to fish, then the survey progresses at v_s = 0.5 ms^{-1}, a value which could well be comparable with v_f. Harden Jones (1968) suggests that herring are capable of migration speeds up to 0.6 ms^{-1}. The swimming capability of fish depends on their size, but adult herring and mackerel can sustain speeds around 1.0 ms^{-1} for long periods (He and Wardle 1988; Lockwood 1989). Sardine may behave similarly

The bias is greatly reduced if the survey can be run alternately with and against the migration, in which case

$$E(\hat{Q}) = Q(1 - (v_f/v_s)^2)$$

and v_s is now nearer the cruising speed of the vessel. Taking the case as v_f = 1 ms^{-1} and v_s = 5 m s^{-1}, the bias is always an underestimate but only of 4%. In practice, the direction of the survey may be decided by other factors such as the coastline or depth contours. If the progress of the survey must be perpendicular to the migration, the surveyed area could be covered twice, in opposite directions with the outward and return tows interleaved. Thus, the survey begins and ends at the same place. This need not be too costly in ship time if the place concerned is the home port. As regards the analysis, the best plan is to treat the outward and return sections as if they were replicate surveys, and to estimate the abundance as the average of the two results.

In the case of WCVI survey it is likely that the only plausible approach is a single direction survey either from north to south or vice versa because the vessel port of origin is east of Vancouver Island, thus multiple tracks up and down the Vancouver Island coast could add significantly to the time required for a survey. In this case v_s can be estimated from the survey timing, if v_f could be estimated the potential bias could be calculated.

4.2.8. Raising point density from tow to stratum density

The estimate of swept volume density has been discussed above, here we address raising this to the area, first through extension to the water column and then from the samples to the strata.

The current approach assumes that the density estimates for 0-15m are proportional to the area density. For computation of absolute biomass, the current approach to raising the observed trawl volume densities to the core area uses a standardised vertical extent of 30m (e.g. Flostrand et al. 2011). This is an important assumption, particularly for absolute estimates and not well supported by the data in the WCVI Survey Report. Even if the survey is to be used as an index, inter-annual variation in abundance with depth may add variance to the index. Evaluating the extent of vertical distribution of Pacific sardine would be beneficial. A number of approaches could be used, such as independent estimation, possibly using acoustics.

The current (2011) method for raising area biomass density to the area of strata is appropriate. Currently, the density estimates from the trawl are combined to calculate a global estimate of density, which is then raised to the abundance for the whole area. In contrast, currently the biological samples are treated so that each fish sampled has equal weight. The analyses presented show that there are annually repeatable trends in fish size with latitude, and indications of differences in sardine density both latitudinally and onshore-offshore (Table 1). Combining all biological samples in the current way removes the influence of the catch rate around the area, and large and small tows are weighted relatively similarly. An alternative is to raise the length and age distributions by the density by trawl. The analysis carried out during the meeting suggests the differences are small, but weighting by tow size is nevertheless the preferred approach. It should be noted that if this is done care needs to be taken if an unusually small sample of length-frequency is taken from a tow giving a high catch rate.

4.2.9. Estimating variance

Given the stratified random survey design, sample variance by stratum is the appropriate method to estimate the precision of the estimate of mean density. Bootstrap of tow data (including biological data) could be used to estimate overall sampling precision. If the design was to be replaced by a different tow allocation regime (e.g., systematic) a geostatistical estimator (Rivoirard *et al.* 2000) would be appropriate.

4.2.10. Abundance estimation

The estimate of total abundance for the core area is the sum of the estimates of total biomass for the individual strata computed by multiplying the estimated stratum density by the stratum area. The sampling variance for estimate of abundance is the sum of the sampling variances by stratum. The survey length-frequency should be the sum of the stratum-specific length-frequencies where the stratum-specific length-frequencies are the sampled length-frequencies weighted by the estimates of density by tow.

4.3. Recommendations for alternative methods or modifications to proposed methods

4.3.1. Gear and Instrumentation

A need for operational standards for the Canadian survey, equipment and tow protocols has been identified. As the survey has not been used directly in an assessment perhaps the need for such a document has not been explicit before. It is recognise that production of such a survey 'manual' can be a substantial piece of work. Such a document should not be fixed but should be considered 'live' being updated as approaches and methods change. Documentation should include *inter alia*:

Documentation of trawl construction

Operational protocols to help making decisions on the validity of tows

Gear instrumentation to be attached to the trawl and parameters to be recorded

Biological sampling and measurement procedures

4.3.2. Calculation of point density from catch data

There is a need to improve the measure of distance towed initially by moving to distance between the GPS position at start and stop, which avoids the need for an estimate of tow speed. Consider use of methods (such as acoustic Doppler current profiler (ADCP) or flow meter) to include volume sampled as the measure to be recorded.

Consider setting the tow start as soon as the standard opening is established and stopping the trawl when trawl geometry is distorted to minimise the influence of catches during shooting and recovery. Evaluate to possibility of including opening-closing devices.

In order to move towards an absolute survey or reduce variance in an index, it would be helpful to evaluate catchability (q). For example investigate the vertical profile of the fish distribution under the vessel using acoustics continuously. Use the trawl sonar to establish a depth distribution profile in and around the mouth of the trawl. Evaluate the possibility of dedicated studies of avoidance as for example has been done for the coastal pelagic species (CPS) acoustic-trawl survey, would be useful to obtain an overview of the impact of these problems.

4.3.3. Definition of the core area

The current (2011) proposal for the core area appears reasonably sensible, but could be modified slightly to make the rationale for the boundary more explicit and to deal with one or two minor additional aspects. It would be helpful to include areas covered by the fisheries, thus giving the survey direct relevance to those involved in the fishery, if possible. Using historical data define the westward extent of the survey at the greater of two criteria maximum based on the extent of non-trivial sardine density: 45km from the coast and the 1000m depth contour.

4.3.4. Influence of environment (habitat)

Evaluate Sardine habitat in WVCI area to see if waters between 12 and 16 ºC off southern and central California are also applicable (Zwolinski et al., 2011). If so consider using habitat estimated immediately prior to the survey to stratify effort annually in the core survey area.

4.3.5. Stratification of the survey area

The current approach of 8 strata gives samples per strata at a similar magnitude, and is thought to be reasonable. The optimal number of strata could be tested by simulation. Consider additional variable such as habitat (see above) to allocate effort in advance of each survey.

4.3.6. Trawl location design (random/ systematic)

It is recomended that the grid be generated before the survey is undertaken, and an algorthim developed to utilize the time optimally, including the use of longer intertow distances during the day. A stratified random grid is thought to be appropriate, but if the survey strategy is modified in the future to use acoustic daytime measures and night trawling this may no longer be the case and could be reconsidered.

4.3.7. Influence of migration (within area)

It is recommended that the potential magnitude of the influence of migration be evaluated for the WCVI survey.

4.3.8. Raising point density from tow to stratum density

The current approach assumes that the density estimates for 0-15m are proportional to the area density. It is recommended that further evaluation should be carried out, and where possible the vertical extent of sardine should be estimated. A number of approaches could be used, such as independent estimation, possibly using acoustics both from the vessel and using the trawl sonar.

4.3.9. Estimating variance

Given the stratified random survey design, sample variance by stratum is the appropriate method to estimate the precision of the estimate of mean density. Bootstrapping of tow data (including biological data) could be used to estimate overall sampling precision. If the design was to be replaced by a different tow allocation regime (e.g., systematic) a geostatistical estimator would be appropriate.

4.3.10. Abundance estimation

The estimate of total abundance for the core area is the sum of the estimates of total biomass for the individual strata computed multiplying the estimated stratum density by the stratum area. The sampling variance for estimate of abundance is the sum of the sampling variances by stratum. The survey length-frequency should be the sum of the stratum-specific length-frequencies where the stratum-specific length-frequencies are the sampled length-frequencies weighted by the estimates of density by tow, given small sample sizes. If this is done it is important to ensure that tows with numerous catches always have a good sample e.g.>200 fish measured.

4.4. Recommendations on application of the methods to the stock assessment and/or management process

4.4.1. Use of historical surveys

The issue here is which surveys could form a useful time-series. There are a number of aspects to the organisation and collection of data to be considered which have changed over time. The three most important of these were identified to be the spatial distribution of the tows, and the changes in sampling by time of day and also by depth.

4.4.1.1. Historical tow locations.

The tow location design has changed over the years. The question is can the data from these designs be used to estimate an internally consistent index of abundance by year? The surveys in 2010 and 2011 are based on random designs, but with a slightly different area basis. It is considered that the sample data from the 2010 and 2011 surveys can be used directly based on the mean of the samples, over the design strata because the tow locations for these years were specifically selected on a random basis. Also, the strata variances calculated from the samples for the surveys during 2010 and 2011 are unbiased estimates of the precision of the estimates.

The 2005 survey was used to compare day and night estimates, not to give a good spatial coverage. Because of this the sample values cannot be relied upon to give an unbiased estimate of either abundance or variance.

The surveys during the other years (1999-2004, 2006, 2008 and 2009) followed a quasi-stratified transect strategy with 5 or 6 sets of tows allocated in lines across the area in an approximately east-west direction. In addition to these tows, in some years extra tows were added in a haphazard way. Raising the mean to the total survey area as done in the WVCI Survey Report may lead to biased estimates of density and variance because the tows were not always located in the area in a way that is designed to be representative (e.g., random, stratified random, or systematic). Inspection of the autocorrelation structure (Figure 3) suggests there is no spatial autocorrelation in the surveys for 1999-2005. Therefore, the samples for these years can be considered to be independently distributed in a statistical sense so the global mean and variance of the samples could be considered as representative.

There is evidence of spatial autocorrelation between the tow observations for 2008 and 2009 (Figure 3). The spatial distribution of tows appears to differ across the area, particularly for 2009. The combination of differential spatial allocation and positive spatial autocorrelation suggests that the global mean and variance may be biased, but any biases may be small. A geostatistical analysis could be used to provide an unbiased estimate of mean and variance. However, for the estimate to be unbiased the location of the hauls must have been on a basis that was not determined by the observed densities during the survey. It is unclear at this stage if that was the case or not.

4.4.1.2. Trawl depth

The depth of trawl (quantified in terms of the depth of the headrope) was more variable in the historical surveys prior to 2005. Indications from the data presented are that there are differences in presence of sardine density with depth, deeper tows tended to give lower densities and a higher proportion of zero sardine tows. It is unclear how much this might influence the mean density, but it is likely to bias the mean density relative to the densities estimated in the more recent surveys. One solution is to use only the shallower tows if these earlier surveys were to be used to construct a time-series.

4.4.1.3. Time of day

Tows were predominantly collected during daylight before 2005, although night data were also collected on some trips. As noted above, catch-rates during the day appear to be more variable than at night. There is also a perception that the catches may be more representative during the night because the fish are more dispersed and would see the trawl later than would be the case during the day. The available resources in 2005 were used to evaluate the effect of sampling during the day and at night. This study indicated again that the presence / absence difference was greater during the day, but the standard deviations for day and night were rather similar (but higher during the day) and the means were not significantly different. However, the lack of significant difference may be due to the small number of samples and the variance in 2005 rather than the absence of important differences. In addition, the 2005 survey was conducted on a different vessel the Frosti rather than the Ricker that was used for all the other surveys. It appears that day and night data are different, but it is unclear by how much. More recent surveys have been carried out at night and CVs are generally lower than those from the earlier predominantly daytime surveys.

Given these range of differences pre/post 2005, it is recommended that the surveys prior to 2005 be considered to be potentially inconsistent with those from 2006 onwards.

4.4.2. Inclusion in future stock assessments

Several items of information obtained from the data collected during the WCVI survey could be included in the stock assessment for Pacific sardine: (a) the index of abundance, (b) the survey length-composition data, and (c) the survey conditional age-at-length data. The major constraint on using the data from the survey in the assessment for Pacific sardine is how to determine the relative proportion of the total population biomass in the core area. There is evidence that this proportion varies among years and direct estimates of the proportion of the total population in the survey area are not available.

Abundance data

The index of abundance could be included in the assessment as an estimate of absolute abundance if it could be argued that catchability for at least one age- or length-class was known. However, given the nature of the survey area (i.e., the location of the core area) such a requirement is primarily compromised because the survey is limited to Canadian waters which do not contain the whole stock. In addition there are other more minor aspects: the index does not extend far offshore and sufficiently far to the north to ensure the entire stock is covered; uncertainty about the extrapolation of densities from the 15m trawl samples to deeper in the water column; estimates of the correct dimensions of trawl swept area; along with the implications of bias caused by surveying north to south in the presence of a north-south migration. Based on all these aspects it is considered that the best use of biomass estimates from the survey would be as the basis for a relative index of abundance (i.e. catchability, q, estimated). The index from the core area could be considered as an index of abundance as long as the factors which relate survey-selected biomass to the expected index for core area remains constant over time. However, time-varying proportions of potential sardine habitat and varying migration (Sections 4.2.4 and 4.2.7) suggest that this assumption is unlikely to be valid. Two suggestions for solutions to the problem of time-varying proportions of the population in the core area are given: (a) the survey index can be assumed to be linearly related to survey-selected biomass, and the survey CVs increased to reflect among-year variability in the proportion of the survey-selected biomass in the core area, or (b) survey catchability can be allowed to vary over time but be related to an independent measure of the proportion of the survey-selected biomass in the core area when the survey is conducted (e.g., be based on the output of a model of potential sardine habitat or sardine migration). The first of these options is most likely to lead to the survey data being ignored in an assessment model because the proportion migrating into Canadian waters is expected to be sufficiently variable such that it might effectively obscure the stock abundance signal. The second option appears to be the most fruitful avenue to explore. This suggests that work to identify whether and how the model of potential sardine habitat can be used to provide a measure of relative survey catchability be carried out.

Size and Age data

The surveys cover the more northerly component of the population which is expected to include the largest and oldest sardine. As such it is recommended that the survey should be assumed to have an asymptotic (e.g., logistic) selectivity pattern; asymptotic to the maximum value at older ages. Size of sardine is observed to vary throughout the area and the Canadian purse-seine fishery and the surveys do not take place at exactly the same locations (the fishery tends to occur closer inshore). It is therefore recommended that the fishery and survey selectivity patterns should be assumed to be different unless it can be shown otherwise by comparing age and length distributions. Nevertheless, given the differences between size and age structure in Canadian water and the population as a whole, it could be that the difference in size and age between catch and survey in Canadian waters is not sufficiently great to demand separate estimation. This decision could be evaluated either within the assessment model through precision of estimates, or through simulation.

Inclusion of historical time-series

There are two approaches for including the available historical data from the WCVI surveys into the assessment: (a) start with the data for 2010 onwards and evaluate whether the model is able to mimic those data and, if so, consider including the data for 2006-09 as well, and (b) attempt to fit the entire time-series and if the model is unable to do this, restrict the data to those for 2010 onwards. Currently it is considered that data prior to 2006 may not be consistent (see 4.4.1 above). Option (a) attempts to fit the 'best' data first. In contrast, option (b) focuses on a longer time-series and reduces the probability of the model mimicking the data spuriously. An additional advantage of option (b) is that it is not expected that the differences in survey design for the 2006-09 surveys from that for the 2011 survey will lead to marked biases in the estimates of biomass. Irrespective of which option is chosen, the assessment report needs to summarize the changes in survey design and protocol over time and explicitly discuss the consistency of the time-series. Given that only the 2011 survey was conducted using what is considered the 'best' design, it is recommended that surveys be conducted during 2012 and 2013 to ensure that at least four years of comparable data are available if an assessment is conducted in 2013.

It is recommended that the following tasks should be undertaken prior to inclusion of the data from WCVI survey in the stock assessment: (a) the sensitivity of the estimates of biomass should be explored to ignoring short and long tows, (b) geostatistical methods (Rivoirard *et al.* 2000) should be applied to estimate abundance (only for the 2008 and 2009 survey), and (c) an index of relative survey q for the WCVI area should be computed using the model of potential habitat.

It is recommended that either: a) a spatial assessment model be developed (which need only be linked to WVCI and Aerial surveys not necessarily perturbing the catch modeling) or b) Stock Synthesis modified so that it is possible to fit simultaneously to two indices of abundance which cover discrete areas such that the annual datum fitted is a weighted sum of each index (where the weighting factor is an estimated parameter). This feature would allow some of the impacts of migration to be accounted for (cancelled out).

It is also recommended that the results of model fits be examined to assess whether the age-classes predicted to be covered by the Aerial and WCVI surveys are realistic.

5. Conclusions

The WVCI Survey Report presentations and additional work carried out during the review provide a good basis to evaluate the performance of the WVCI trawl survey.

The indication is that the survey is currently being performed in a way that should allow a consistent index of abundance for Pacific Sardine in Canadian waters to be produced. It would be helpful to develop a survey protocol document covering all aspects of design, implementation and analysis. Such a living document would be helpful to maintain standards and track development in the future.

The WVCI trawl survey time series can be considered to give estimates of distribution of abundance of Pacific Sardine for the survey area. Minor reanalysis is required to update estimates of precision for some years. Some limited exploration is required to evaluate the sensitivity of the abundance estimates to tow length. Some model and index development is required primarily to determine the proportion of Pacific sardine in Canadian waters at the time of the survey, before the best use of the survey can be obtained within the assessment.

6. Recommendations

The following recommendations arising from the review are summarized below ranked in order of importance: H-high; M-medium; L-low; *-N/A):

1) Surveys should be conducted annually to ensure a time-series of comparable estimates is developed as quickly as possible. It is particularly important that surveys are conducted during 2012 and 2013 to ensure that at least four years of comparable data are available if an assessment is conducted in 2013. If it becomes necessary to conduct surveys every other year (rather than annually), it would be preferable to conduct the survey during a year in which a full stock assessment is conducted (H).
2) Fishing at night should be continued (H).
3) Protocols for tow duration should be established in advance of the survey (H).
4) Do not use GPS tow speed to compute tow length. Instead, use the start and stop points. If possible, ocean current velocities should be recorded for later impact studies (H).
5) Establish a trawl manual that describes how the gear used is standardized, including trawl drawings and rigging that can be easily interpreted by users. This should be a 'living' document, which is updated as needed. Develop and document standard routines for trawl operation that include better utilization of the trawl sonar output for standardizing and quality ensuring each tow (H).
6) The survey grid should be generated before the survey is undertaken and an algorthim developed to utilize the time optimally, including the use of longer intertow distances during the day (H).

7) For future surveys, create a larger number of potential tow locations so that the number of randomly drawn tows will represent a smaller percentage of possible tow locations (and more a random spatial selection) (H).

8) The conditional age-at-length data for the survey should be computed from the raw age-length data points (without weighting), but the length-frequency data should be scaled to tow density, used to compute stratum length-frequencies and these summed to obtain the length-frequency for the entire survey (H).

9) Extend the USA habitat model northward to the Alaska border and use this model to provide a measure of relative survey catchability (H).

10) The WCVI survey should be assumed to have an asymptotic (e.g. logistic) selectivity pattern (H).

11) The Canadian fishery and WCVI survey selectivity patterns should be assumed to be different unless it can be shown otherwise (H).

12) The following tasks should be undertaken prior to inclusion of the data from WCVI survey in the stock assessment: (a) the sensitivity of the estimates of biomass to ignoring short and long tows should be explored, (b) geostatistical methods should be applied to estimate abundance (only for the 2008 and 2009 surveys), and (c) measures of relative survey q for the WCVI area should be computed using the model of potential habitat (H).

13) The results of model fits should be examined to assess whether the age-classes predicted to be covered by the aerial and WCVI surveys are biologically plausible (H)

14) Evaluate the possibility of using trawl opening and closing devices in case trawling at various depths becomes necessary (M).

15) Investigate the potential magnitude of migration on survey bias (M).

16) Develop a process for measuring volume sampled (M).

17) Investigate the impact of variation in the depth of sardine. Monitor the depth distribution of sardine and consider changing the depth profile of the trawls if this changes (M). Investigate the assumption of a standardized vertical extent of 30m (M).

18) Develop a modelling framework which can address having data for two subsets of the total stock area (aerial and WCVI surveys), along with the consequences of time-varying migration. For example, (a) Stock Synthesis could be modified so that it is possible to fit simultaneously to two indices of abundance which cover discrete areas such that the datum fitted is a weighted sum of each index, or (b) a two-area model which explicitly includes areas could be developed (M).

19) Carry out avoidance studies to assess the potential impact of fish behaviour on the survey outcome. Over the short term, this would include comparing vertical profiles from vessel acoustics and the trawl sonar. Over the long term, more advanced studies, e.g. as done by the CPS acoustic-trawl survey team, would be useful (L).

20) Should survey vessels change in the future, the impact of changes in survey catchability should be evaluated and monitored regularly, ideally using some form of calibration experiment. (*)

21) Compare daytime acoustic biomass estimates with trawl-based estimates taken at the same time. If this proves to be impractical, then compare daytime acoustic estimates with trawl estimates taken the previous night. (*)

7. References

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Appendix 1: Bibliography of materials provided for review

Primary Documents

Linnea Flostrand, Jake Schweigert, Vanessa Hodes, 2012 Canadian west coast of Vancouver Island summer sardine research trawl surveys,1999-2011, sardine catch density and length, sex and age data sets. Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, B.C. V9T 6N7

Background documents

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Terms of Reference Pacific Sardine 2011 Seasonal Abundance and Migration in British Columbia and Harvest Advice for 2012 Pacific Regional Advisory Process January 10, 2012 Nanaimo, British Columbia.

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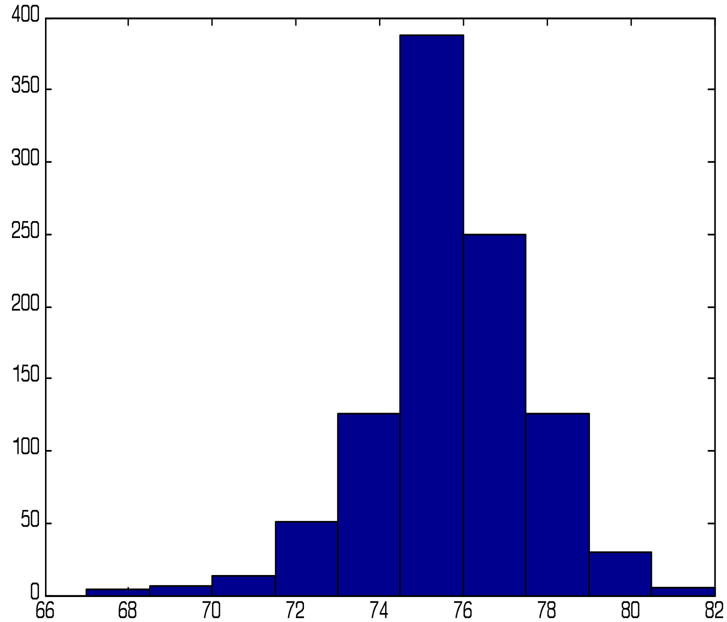

Figure 1. Number of randomly located tows in a fixed time with the minimum track obtained using the travelling salesman algorithm. (9 days with a survey speed of 10 knots and trawling time of 1.5 hours in a 14,400 N.mi^2 area) This compares with a systematic grid of 64 tows in the same time period.

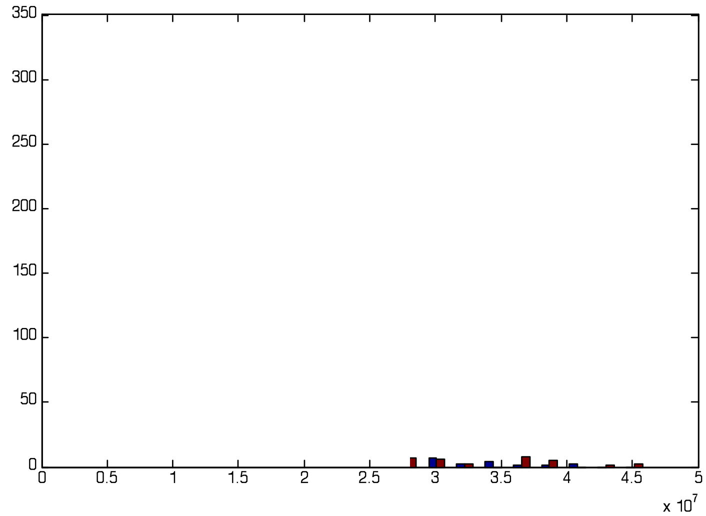

Figure 2. Frequency distribution of estimates of total abundance for a systematic survey design (red) and a random survey design (blue) for: a) a high variance, low correlation surface (upper panel); and b) a lower variance, but more correlated surface (lower panel).

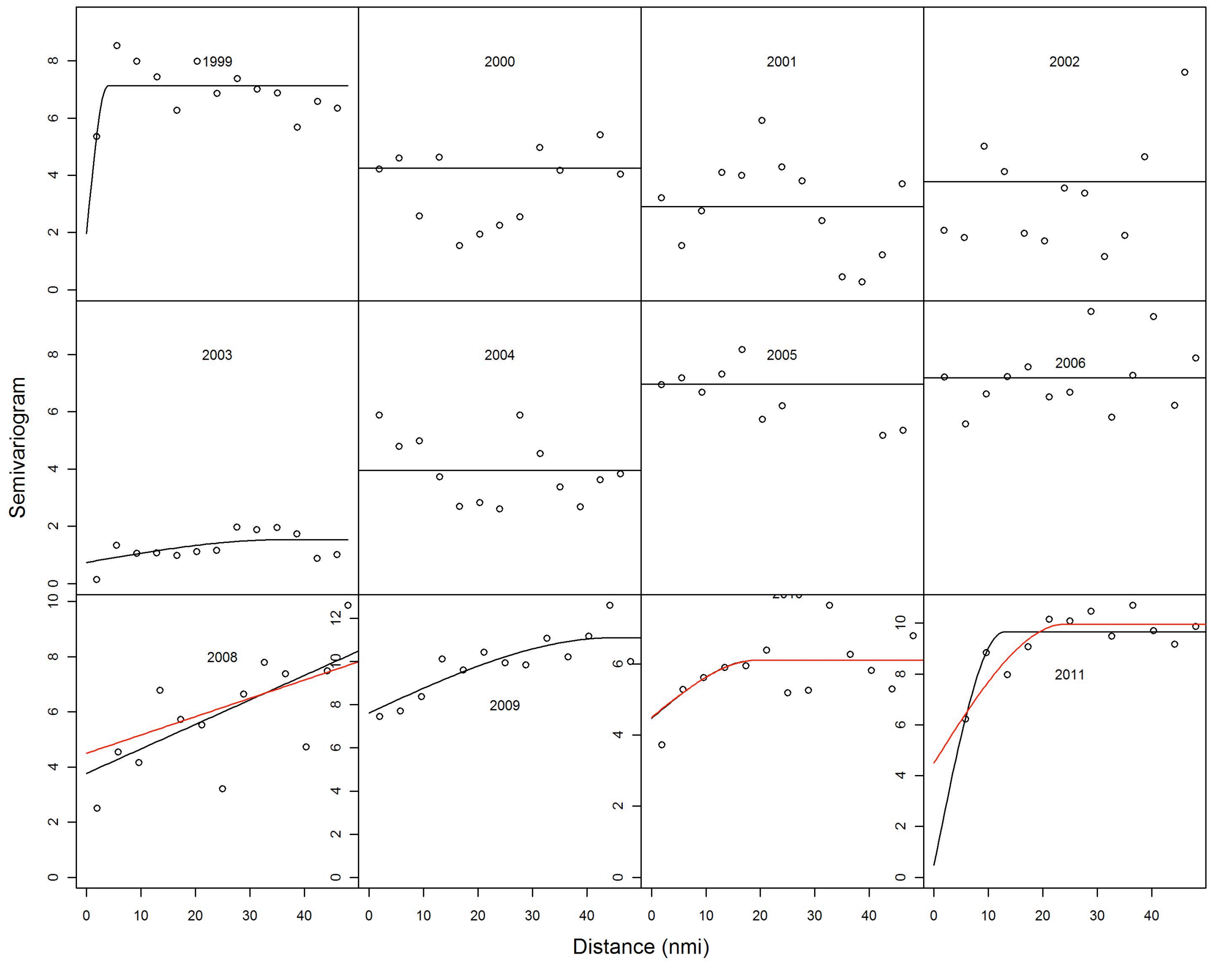

Figure 3. Empirical variograms for the surveys (dotted) and fitted parametric spherical variograms (lines).(with thanks to Juan Zwolinski for preparing this figure during the meeting).

Appendix 2: Statement of Work for John Simmonds

External Independent Peer Review by the Center for Independent Experts

Panel Methods Review of the Canadian Swept-Area Trawl Survey conducted along the West Coast of Vancouver Island for Inclusion into the Pacific Sardine Stock Assessment

May 29-31, 2012

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The CIE reviewers will serve on a Methodology Review (MR) Panel and will be expected to participate in the review of the Canadian swept-area trawl survey conducted along the West Coast of Vancouver Island (WCVI Survey) for inclusion into the Pacific sardine stock assessment. The Pacific sardine stock is assessed regularly (currently, every year) by SWFSC scientists and the Pacific Fishery Management Council (PFMC) uses the resulting biomass estimate to establish an annual harvest guideline (quota). Independent peer review is required by the PFMC review process. The stock assessment data and model are formally reviewed by a Stock Assessment Review (STAR) Panel once every three years, with a coastal pelagic species subcommittee of the SSC reviewing updates in interim years. Fishery-independent data surveys, e.g., CalCOFI, acoustic, and aerial surveys are done annually to provide information to the model. Both the 2009 and 2011 Pacific Sardine STAR Panels recommended the addition of the WCVI survey as an additional fishery-independent data set, stating that the data set is potentially valuable since it provides abundance information for a large area within Canadian waters. Inclusion of the WCVI survey would also provide valuable insights into the northern most extension of the population, the largest size classes, and the timing and extent of migration during different years.

The MR Panel will review all pertinent survey and stock assessment documents and any other relevant information for Pacific sardine, work with the survey teams to make necessary revisions, and produce a MR Panel report for use by the PFMC and other interested persons for developing management recommendations for the fishery. The PFMC's Terms of Reference (ToRs) for the MR Panel review are attached in **Annex 2**. The tentative agenda of the Panel review meeting is attached in **Annex 3**. Finally, a Panel summary report template is attached as **Annex 4**.

Requirements for CIE Reviewer: Two CIE reviewers shall participate during a panel review meeting in La Jolla, California during 29-31 May, and shall conduct an impartial and independent peer review accordance with the SoW and ToRs herein. The CIE reviewers shall have the expertise as listed in the following descending order of importance:

- The CIE reviewers shall have expertise in the design and execution of fishery-independent surveys, such as swept-area trawls, for coastal pelagic fishes.
- The CIE reviewers shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., ‘forward-simulation’ models (such as Stock Synthesis, SS) and it is desirable to have familiarity in ‘backward-simulation’ models (such as Virtual Population Analysis, VPA).
- The CIE reviewers shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and application of other fishery-independent sampling surveys such as aerial surveys and underwater acoustic technology to estimate fish abundance for stock assessments.

The CIE reviewer’s duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review process.

Location/Date of Peer Review: The CIE reviewer shall conduct an independent peer review during the MR Panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 3333 North Torrey Pines Court, La Jolla, California from May 29-31, 2012.

Statement of Tasks: The CIE reviewer shall complete the following tasks in accordance with the SoW, ToRs and Schedule of Milestones and Deliverables specified herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering committee, the CIE shall provide the CIE reviewer information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewer. The NMFS Project Contact is responsible for providing the CIE reviewer with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website:

http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewer all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewer shall read all documents in preparation for the peer review, for example:

- Recent Canadian WCVI survey documents including proceedings from the most recent Canadian Stock Assessment review (10 January 2012),
- Recent stock assessment documents since 2009,
- MR Panel- and SSC-related documents pertaining to reviews of past assessments,
- CIE-related summary reports pertaining to survey design and past assessments, and
- Miscellaneous documents, such as ToR, logistical considerations.

Pre-review documents will be provided up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewer is responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein.

Panel Review Meeting: The CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the peer review, and any SoW or ToR modification prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewer and MR Panel chair are described in Annex 2 (see p. 6-8). The CIE reviewer will serve a role that is equivalent to the other panelists, differing only in the fact that he/she is considered an 'external' member (i.e., outside the Pacific Fishery Management Council family and not involved in management or assessment of West Coast CPS). The CIE reviewer will serve at the behest of the MR Panel Chair, adhering to all aspects of the PFMC's ToR as described in Annex 2. The MR Panel chair is responsible for: 1) developing an agenda, 2) ensuring that MR Panel members (including the CIE reviewer), and STAT Teams follow the Terms of Reference, 3) participating in the review of the assessment (along with the CIE reviewer), 4) guiding the MR Panel (including the CIE reviewer) and STAT Team to mutually agreeable solutions.

The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewer shall complete an independent peer review report in accordance with the SoW. The CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. The CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: The CIE reviewer will assist the Chair of the panel review meeting with contributions to the Summary Report. The CIE reviewer is not required to reach a consensus, and should instead provide a brief summary of their views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewer: The following chronological list of tasks shall be completed by the CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;
2) Participate during the panel review meeting in La Jolla, California, from May 29-31, 2012, as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Annex 2);
3) No later than June 15, 2012, the CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die., CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

April 17, 2012	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
May 15, 2012	NMFS Project Contact sends the CIE Reviewer the pre-review documents
May 29-31, 2012	The reviewer participates and conducts an independent peer review during the panel review meeting
June 15, 2012	CIE reviewer submits draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
June 29, 2012	CIE submits CIE independent peer review reports to the COTR
July 13, 2012	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within

10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewer to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Annex 1, (2) the CIE report shall address each ToR as specified in Annex 2, (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Support Personnel:

William Michaels, Program Manager, COTR

NMFS Office of Science and Technology

1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910

William.Michaels@noaa.gov Phone: 301-427-8155

Manoj Shivlani, CIE Lead Coordinator

Northern Taiga Ventures, Inc.

10600 SW 131st Court, Miami, FL 33186

shivlanim@bellsouth.net Phone: 305-383-4229

Key Personnel:

Dale Sweetnam, **NMFS Project Contact**
Fisheries Resources Division, Southwest Fisheries Science Center,
8604 La Jolla Shores Dr., La Jolla, CA 92037
Dale.Sweetnam@noaa.gov Phone: 858-546-7170

Dr. Russ Vetter, Director, FRD,
Fisheries Resources Division, Southwest Fisheries Science Center,
8604 La Jolla Shores Dr., La Jolla, CA 92037
Russ.Vetter@noaa.gov Phone: 858-546-7125

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the Reviewer's report shall consist of the following sections, in accordance with the ToRs: Background, Description of the Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Recommendations and Conclusion.

   a. The Reviewer should describe in their own words the review activities completed during the panel meeting, including providing a detailed summary of findings, recommendations, and conclusion.

   b. The Reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where they were divergent.

   c. The Reviewer should elaborate on any points raised in the Summary Report that might require clarification.

   d. The Reviewer shall provide a critique of the review process, including suggestions for improving both the process and products.

   e. The CIE report shall be a stand-alone document for others to understand the proceedings and findings of the meeting without having to read the Panel report. The report shall be an independent review of each ToR, and shall not simply repeat the contents of the Panel report.

3. The Reviewer's report shall include the following separate appendices:

   Appendix 1: Bibliography of materials provided for review

   Appendix 2: The CIE Statement of Work

   Appendix 3: Panel Membership or other pertinent information from the review meeting.

Annex 2: Terms of Reference for the Peer Review of the WCVI Survey

Each CIE reviewer is one of the four equal members of the MR panel. The principal responsibilities of the MR Panel are to review survey design and stock assessment data inputs, analytical models, and to provide complete MR Panel reports.

Along with the entire MR Panel, the CIE Reviewer's duties include:

1. Review documents pertinent to the topic under consideration,
2. Evaluate the technical merits and deficiencies of the proposed method(s) during the panel meeting and work with the proponents to correct deficiencies,
3. Provide recommendations for alternative methods or modifications to proposed methods, or both, as appropriate during the panel meeting,
4. Provide recommendations on application of the methods to the stock assessment and/or management process,
5. Document meeting discussions,
6. Provide complete panel reports.

The MR Panel should strive for a risk neutral approach in its reports and deliberations and ensure that the research surveys, data collection, data analyses and other scientific techniques in support of the Pacific sardine stock assessment are the best available scientific information and facilitate the use of information by the Council.

The MR Panel, including the CIE Reviewers, is responsible for determining if a technical analysis is sufficiently complete. It is their responsibility to identify scientific techniques that cannot be reviewed or completed for any reason. The decision that a research survey may be incorporated into an assessment should be made by Panel consensus. If agreement cannot be reached, then the nature of the disagreement must be described in the Panels' and CIE Reviewer's reports.

Recommendations and requests to the STAT Team for additional or revised analyses must be clear, explicit, and in writing. A written summary of discussion on significant technical points and lists of all MR Panel recommendations and requests to the STAT Team are required in the MR Panel’s report. This should be completed (at least in draft form) prior to the end of the meeting. It is the chair and Panel’s responsibility to carry out any follow-up review of work that is required.

Annex 3: Participants and Agenda

Methodology Review Panel Members:

André Punt (Chair), Scientific and Statistical Committee (SSC), University of Washington

Ray Conser, SSC, NMFS, Southwest Fisheries Science Center

Olav Rune Godø, Center for Independent Experts (CIE)

John Simmonds, Center for Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives:

Kirk Lynn, Coastal Pelagic Species Management Team (CPSMT)

Mike Okoniewski, Coastal Pelagic Species Advisory Subpanel (CPSAS)

Kerry Griffin, Council Staff

Technical Team:

Linnea Flostrand, DFO, Canada

Jake Schweigert, DFO, Canada

Paul Crone, NMFS, SWFSC

Others in Attendance

David Demer, NMFS, SWFSC

Emmanis Dorval, NMFS, SWFSC

Kevin Hill, NMFS, SWFSC

Kristen Koch, NMFS, SWFSC

Nancy Lo, NMFS, SWFSC

Josh Lindsay, NMFS, SWFSC

Sarah Shoffler, NMFS, SWFSC

Dale Sweetnam, NMFS, SWFSC

Russ Vetter, NMFS, SWFSC

Cisco Werner, NMFS, SWFSC

Juan Zwolinski, NMFS, SWFSC

Agenda

<u>TUESDAY, MAY 29, 2012 – 8:30 A.M.</u>

A. Call to Order, Administrative Matters, and Approval of Agenda — Andre Punt

Facilities and Logistics — Dale Sweetnam

Work Plan and Terms of Reference — Kerry Griffin

Report Outline and Appointment of Rapporteurs — Andre Punt

B. History of the WCVI Trawl Survey — Flostrand/Schweigert

(9 a.m., 1 hour)

BREAK

C. WCVI Trawl Survey Methods and Results — Flostrand/Schweigert

(10:30 a.m., 2 hours)

LUNCH

D. Inclusion of the WCVI Trawl Survey in the U.S. Sardine Assessment — Paul Crone

(1:30 p.m., 1 hour)

E. Panel Discussion and Panel Requests — Panel

(2:30 p.m., 0.5 hours)

BREAK

F. Public Comment, General Issues

(3:30 p.m., 1.5 hours)

ADJOURN DAY 1

<u>WEDNESDAY, MAY 30 – 8:00 A.M.</u>

G. Responses to Panel Requests — Flostrand/Schweigert

(8 a.m., 2.5 hours)

BREAK

H. Panel Discussion and Requests — Panel

(11 a.m., 1.5 hours)

LUNCH

I. Report Drafting — Panel

(1:30 p.m., 1.5 hours)

BREAK

J. Responses to Panel Requests — Flostrand/Schweigert

(3:30 p.m., 1 hour)

K. Discussion and Panel Requests Panel

(4:30 p.m., 0.5 hours)

ADJOURN DAY 2

<u>THURSDAY, MAY 31, 2012 – 8:00 A.M.</u>

L. Responses to Panel Requests Flostrand/Schweigert

(8 a.m., 1 hour)

M. Finalize Panel Report Panel

(9 a.m., 1.5 hours)

BREAK

M. Finalize Panel Report (continued) Panel

(11 a.m., 2 hours)

ADJOURN